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Full Rate General Complex Orthogonal Space-Time Block Code for 8-Transmit Antenna

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Abstract

The need for mobile communication systems with high data rates and improved link quality for a variety of application has dramatically increased in recent years. Multiple antenna systems are an efficient means for increasing the performance. To utilize the huge potential of multiple antennas it is necessary to choose transmit strategies, referred to as space–time block code (STBC). For real orthogonal STBC design the code rate 1 can be achieved, for any number of transmit antenna. For complex orthogonal STBCs of two, three, and four transmit antennas have achieved rate of 1, ¾ and ¾ respectively. Complex orthogonal designs STBCs for other numbers of transmits antennas exhibit rates of 1, 7/11 and 3/5 for four, five and six antennas respectively. In this paper we achieved full rate, generalized complex orthogonal space time block code for 8 transmit antenna.

Keywords- Diversity, Space-Time Block Code (STBC), Multiple-Input Multiple-Output (MIMO), Complex Orthogonal Space-Time Block Code (COSTBC).

1. Introduction

Wireless communications has made a tremendous impact on the lifestyle of a human being. It is very difficult to survive without wireless in some form or the other. As compared to fixed wireless systems, today's wireless networks provide high speed mobility (mobile users in fast vehicles) for voice as well as data traffic. The time-varying nature of wireless channels, such as fading, multipath makes it difficult for wireless system designers to satisfy the ever-increasing expectations of mobile users in terms of data rate

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and Quality of Service (QoS). The limited radio spectrum and limitation on the processing power availability in the portable handheld unit of mobile user are the other important constraints in designing wireless systems.

When we talk about multiple-input multiple-output (MIMO) then diversity can be achieved by space-time block code (STBC) design. Whereas space time block code (STBC) design is just like a matrix. It has to be mentioned that to design a good space–time block code is not so easy. Wireless systems consisting of a transmitter, a radio channel and a receiver are categorized by their number of inputs and outputs. The simplest configuration is a single antenna at both sides of the wireless link, denoted as single-input/single output (SISO) system. Using multiple antennas on one or both sides of the communication link are denotes as multiple input/multiple output (MIMO) systems

To utilize the huge potential of multiple antennas it is necessary to choose transmit strategies, referred to as space –time block code (STBC). With such a system the throughput can be increased by simultaneously transmitting different streams of data on the different transmit antennas but at the same carrier frequency. But these parallel data streams are mixed up in the air, and they can be recovered at the receiver by using space-time block code (STBC). Space-time block codes from orthogonal designs first proposed by Alamouti [1] and after that Tarokh- Jafarkhani-Calderbank [2][3] have involved considerable attention due to the fast maximum-likelihood (ML) decoding and the full diversity. There are two classes of space-time block codes from orthogonal designs. One class consists of those from real orthogonal designs for real signal constellations such as pulse amplitude modulation (PAM). These codes have been well developed. There are systematic constructions with optimal symbol transmission rate one for any number of transmit antennas [4][6] which are based on the Hurwitz–Radon constructive theory. The other class consists of those from complex orthogonal designs for complex constellations for high data rates such as QAM and PSK.

2. Generalized Complex Orthogonal Space Time Block Code

This correspondence follows the terminologies of [2]. Firstly we review the concept of the (generalized) complex orthogonal design and some known designs of complex orthogonal space-time block code (COSTBC) rate 1, ¾ for different antennas [1], [2],[3] [4], [7]. We then present a new full rate general complex orthogonal space time block code for 4 transmit antenna.

2.1 Definition: Generalized Complex Orthogonal Design : A generalized complex orthogonal design (GCOD) in variables $x_1, x_2, ...x_k$ is a p x n matrix G such that: The entries of G are $0, \pm x_1, \pm x_2, ..., \pm x_k,$, or their conjugates $\pm x_1^*, \pm x_2^*, ..., \pm x_k^*$ or multiples of them by i where $i = \sqrt{-1}$; $G^H G = D$,where G^H is the complex conjugate and transpose of G and D is an n x n diagonal matrix with the (i,i)th diagonal element of the form $l_{i,1}|x_1|^2 + l_{i,2}|x_2|^2 + l_{i,3}|x_3|^2 + ... + l_{i,k}|x_k|^2$ where all coefficients $l_{i,1}, l_{i,2}, l_{i,3}, ..., l_{i,k}$ are strictly positive numbers. If $G^H G = \left(|x_1|^2 + |x_2|^2 + ... + |x_k|^2\right) I_{nxn}$ then, G is called a complex orthogonal design (COD). The rate of G is defined as R = k/p. If p = n = k, then G is a classical complex orthogonal design (COD for short). The decoding at the receiver is reasonably fast, and the diversity of the code is not lesser.

The first space time block code from complex orthogonal design was proposed in Alamouti [1] for two transmit antennas. It is the following 2x2 complex orthogonal design in variables x_1 and x_2.

$$G_2 = \begin{pmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \end{pmatrix} \tag{1}$$

Suppose that there are 2^b signals in the constellation. The first time slot, 2b bits arrive at the encoder and select two complex symbols x_1 and x_2.These symbols are transmitted simultaneously from antennas one and two, respectively. At the second time slot, signals $-x_2^*$ and x_1^* are transmitted simultaneously from antennas one and two, respectively. Clearly, the rate of G_2 achieves the maximum rate $R = k / p = 2/2 = 1$ [1].

For n = 3 and n = 4 transmit antennas, there are complex orthogonal designs of rate R = ¾ [2], [4], [5] and as an example for three transmit antennas, the G_3 is given by

$$G_3 = \begin{bmatrix} x_1 & x_2 & x_3 \\ -x_2^* & x_1^* & 0 \\ x_3^* & 0 & -x_1^* \\ 0 & x_3^* & -x_2^* \end{bmatrix} \tag{2}$$

and for four transmit antennas G_4 is given by

$$G_4 = \begin{bmatrix} x_1 & x_2 & x_3 & 0 \\ -x_2^* & x_1^* & 0 & x_3 \\ x_3^* & 0 & -x_1^* & x_2 \\ 0 & x_3^* & -x_2^* & -x_1 \end{bmatrix} \tag{3}$$

Where G_3 matrix is acquired by taking the first three columns of G_4. The rate of G_4, is R = ¾, where codeword with block length p = 4, with information symbols k =3. By now, the existing designs of rate greater than ½ are only G_2 ,G_3 , and G_4 , with rates 1, ¾ and ¾, respectively. Fast ML decoding and the full diversity are the advantages of the general complex orthogonal design. Such a diagonal form of D guarantees the fast ML decoding, since the orthogonal columns $x_1, x_2, ...x_k$ from each other at the decoder.

For n = 5 and n = 6 transmit antennas, there are complex orthogonal designs of rate greater than R = ½ [7], but lesser than rate one. Whereas for antenna five space-time block code matrix is constructed from G_4 . Where in [7], a new class of complex orthogonal designs was proposed for n = 5, it may check that $G_5^H G_5 = D$,where D is a 5 X 5 matrix with the (i, i)th diagonal element D (i, i) of the form of

$$D(1,1) = D(2,2) = D(3,3) = D(4,4) = \sum_{m=1}^{7} |x_m|^2 , \quad D(5,5) = 2\sum_{m=1}^{3} |x_m|^2 + \sum_{m=4}^{7} |x_m|^2$$

So, for n =5, transmit antennas, complex orthogonal designs of rate is R=7/11=0.6364[7], is achieved for G_5 matrix[7].

3. Proposed Full Rate General Complex orthogonal Space-Time Block Code for 8-Transmit Antenna

Here, a Proposed generalized complex orthogonal space-time block code(COSTBC) design of rate greater than ¾ for 8 transmit antenna is achieved. Where the block length with codeword p=8,and the carriers information symbols k=8.Thus one can get $R = k / p = 8/8 = 1$ (full rate)[10]. So the new matrix 8 x 8 is given by

$$G_8^{new} = \begin{bmatrix} x_1 & x_2 & x_3 & x_4^* & x_5 & x_6 & x_7 & x_8^* \\ -x_2^* & x_1^* & -x_4 & x_3^* & -x_{*}^{6} & x_5^* & -x_8 & x_7^* \\ -x_3^* & x_4 & x_1^* & -x_2^* & -x_7^* & x_8 & x_5^* & -x_6^* \\ -x_4^* & -x_3 & x_2 & x_1 & -x_8^* & -x_7 & x_6 & x_5 \\ x_5 & x_6 & x_7 & x_8^* & x_1 & x_2 & x_3 & x_4^* \\ -x_6^* & x_5^* & -x_8 & x_7^* & -x_2^* & x_1^* & -x_4 & x_3^* \\ -x_7^* & x_8 & x_5^* & -x_6^* & -x_3^* & x_4 & x_1^* & -x_2^* \\ -x_8^* & -x_7 & x_6 & x_5 & -x_4^* & -x_3 & x_2 & x_1 \end{bmatrix} \tag{4}$$

From the resulting matrix in equation (4), we can check that $G_8^{new} G_8^{new^H} = D$ where D is a 8x 8 diagonal matrix with the (i, i)th diagonal element D (i, i) of the form is

$$D(1,1) = D(2,2) = D(3,3) = D(4,4) = D(5,5) = D(6,6) = D(7,7) = D(8,8) = \sum_{m=1}^{8} |x_m|^2$$

It is clear to say now that symbols $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8$ and their complex conjugates $x_1^*, x_2^*, x_3^*, x_4^*, x_5^*, x_6^*, x_7^*, x_8^*$ appear in the matrix of G_8^{new} and rate is achieved one (full rate).

4. Conclusion

Design of complex orthogonal space-time block codes involves the mathematics literature motivated from the compositions of quadratic forms [8, 9]. In Recent past Space time coding is also using orthogonal Complex designs. Real and complex orthogonal Codes are used to construct space-time block codes for almost all the Modulation Schemes Viz PAM and PSK/QPSK/QAM/BPSK signals, respectively. Unlike the real orthogonal Codes, the Complex orthogonal Codes are difficult to deal with. But they can provide high transmission rates because the permit the Complex signals Constellation.

Here in this Paper the Complex orthogonal space-time block codes (COSTBC) satisfy full diversity as well as fast ML decoding conditions. In the previous work the designs of rate greater than ½ and less than 1 were give only for three or four transmit antennas with rate of ¾ and only the code rate 1 was for two transmit antenna and 4 transmit antennas. In this work we Propose the new complex orthogonal design with full code rate using 8 transmit antennas. By increasing number of transmit antennas the bit error rate decreases and hence the Performance of the Wireless Communication system increases.

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